FIREBALL CALCULATIONS

SHOT WRANGELL

OPERATION HARDTACK, PHASE II

PROJECT 15.1

Report No. B-2064
4 March 1960

Prepared by J. E. Campbell
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Approved by D. F. Seacord, Jr.
D. F. Seacord, Jr.

EDGERTON, GERMESHAUSEN & GRIER, INC.
Boston, Mass. Santa Barbara, Calif. Las Vegas, Nev.

Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

29 May 1996

ISST

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OCD/MR. BILL BUSH

SUBJECT: Documents for DTIC System

There is no record of your office receiving the following reports:

EGG-B-2064 (4 March 1960)
Fireball Calculations Shot
Wrangell Operation Hardtack
Phase II, Project 15.1

EGG-B-2063 (4 March 1960)
Fireball Calculations Shot Humboldt
Operation Hardtack Phase II
Project 15.1

Both documents are now approved for public release.

Therefore, we are transmitting copies for inclusion into the DTIC system, if not found there.

Ardith Jarrett

ARDITH JARRETT
Chief, Technical Support

Enclosure:
A/S

FIREBALL CALCULATIONS - SHOT WRANGELL

1.0 INTRODUCTION

Shot Wrangell was a 1500-foot balloon shot sponsored by LRL and detonated on 22 October 1958 in Area B-Fa of the Nevada Test Site at 0850 PST.

The fireball yield was 67.3 tons ± 5.0 tons.

2.0 CAMERA INSTRUMENTATION AND OPERATION

Photographic coverage of fireball growth was provided by four high-speed Eastman cameras, two each at Station F-362 (6 x 6 No. 2) and Station F-369 (6 x 6 No. 3). In addition, two Rapatronic cameras were located at each of these stations to record early fireball growth.

Three Eastman cameras and three Rapatronics provided good records. The remaining Eastman and Rapatronic, because of malfunctions, did not provide records suitable for analysis.

The station locations, together with the burst location, are shown in Figure 1. Figure 2 contains the Survey Data.

3.0 RESULTS

Application of phi-comparison (EG&G Report No. B-1869) for Shot Wrangell indicates a yield of 67.3 tons ± 5.0 tons.

An air density of 1.057 grams per liter was used in the yield calculations, based on a pressure of 863 millibars, a temperature of 11.1°C, and a relative humidity of 13 percent at the height of the device at shot time.

The following table shows the Wrangell yield as obtained by a phi-comparison to various other low-yield devices:

Comparison Shot	Wrangell Yield Tons
Air Drop	
Wasp	66.74
Buster Baker	62.41
Wasp'	66.38
Ranger E	63.56
Ranger A	66.73
Osage	71.64
Tower	
Hornet	64.97
Chaves	72.97
Rio Arriba	73.19
Quay	64.44
Humboldt	64.58
Balloon	
Hidalgo	66.46
Lea	71.03
	$\overline{W}$ = 67.3 tons

Diameter-time and phi-time plots are shown in Figures 3 and 4.

The following data sheets are included for each film:

(a) Photo Plan and Photo Loading Chart

(b) Camera Data and Calculation Sheet

(c) Diameter Measurement Sheet

(d) E-102 Print-Out Sheet of D, t, and $\emptyset$

Appendix A contains photographic examples of early fireball growth.

The zero-frame times of the Eastman records were determined by comparison with the Rapatronic diameter-time data.

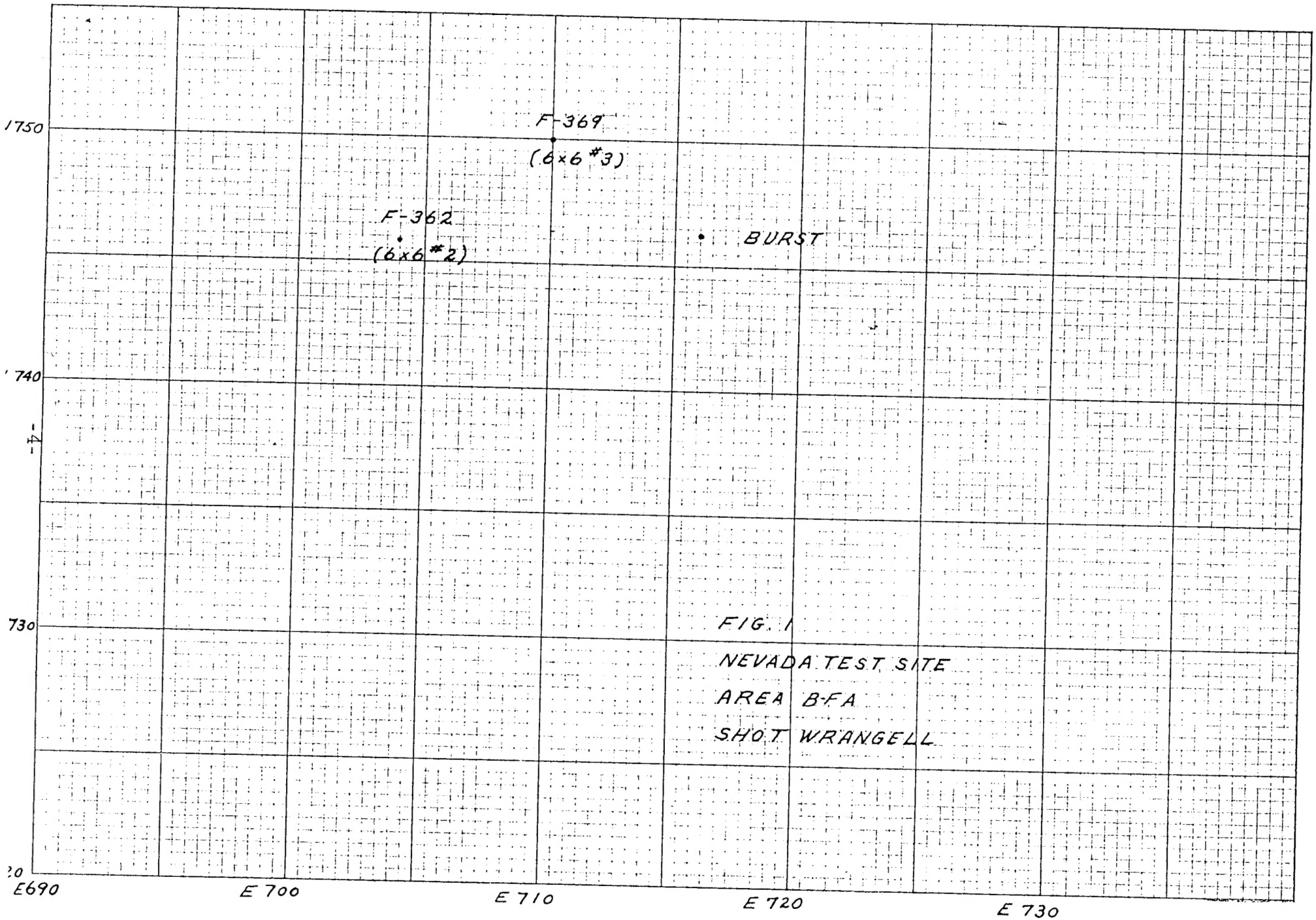


FIG. 1

NEVADA TEST SITE

AREA B-FA

SHOT WRANGELL

FIG. 2

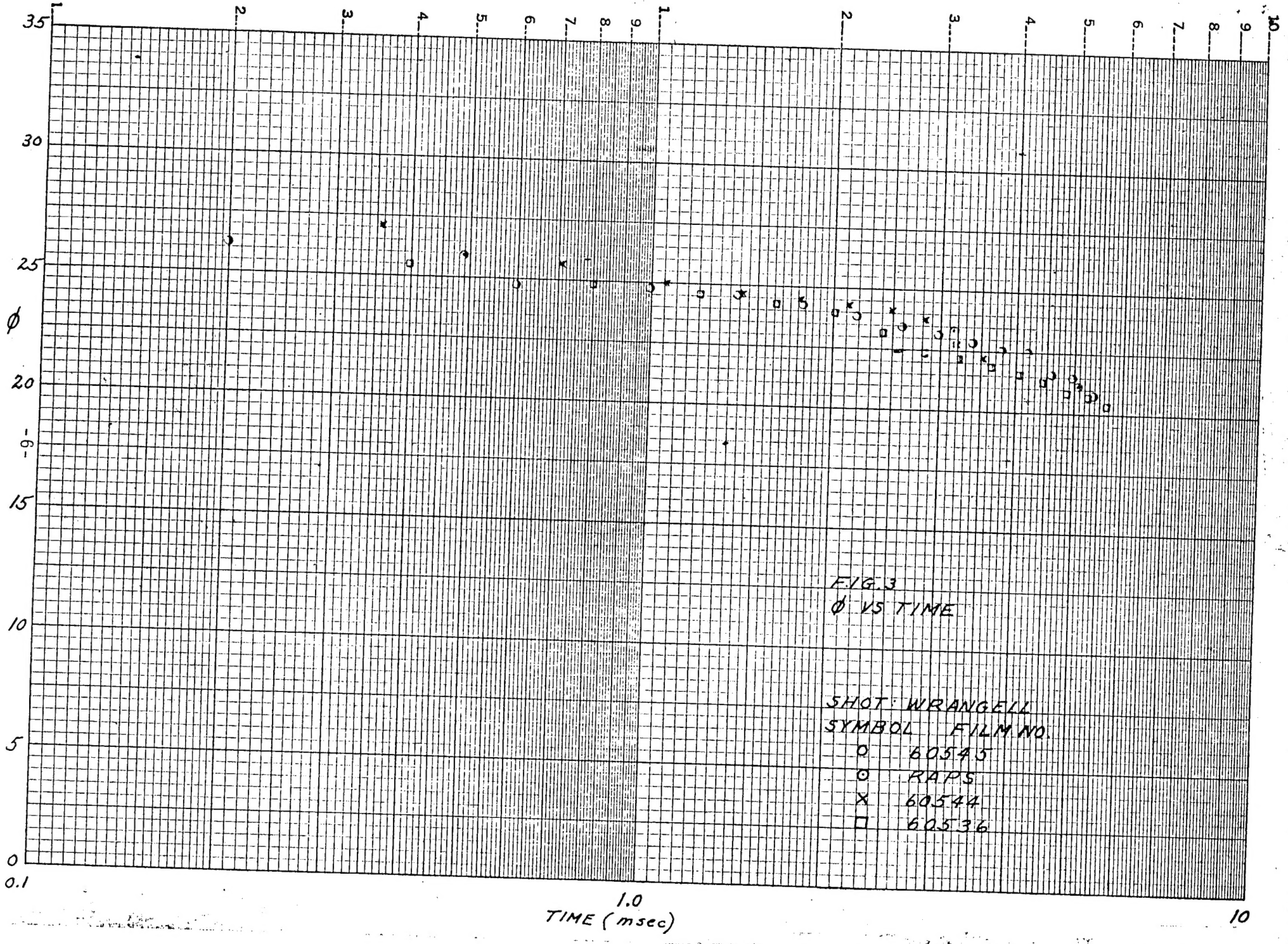
DATE 10/22/58

SURVEY DATA

GZ STA. BFA

STA.	COORDINATES			FROM Photo sta.			DIST. HOR.		TANGENTS		ANGLES	
	N	E	Z	ΔN	ΔE	ΔZ	FT.	M.	ΔN/ΔE	ΔZ/DIST.	BRG	TILT
BFA	746250	716000	4577*									
F362 6×6 #1	745844	703948	3091	+406	+12052	1486	12058.8	3675.6	29.6847	0.12318	88°04'	7°01'
F362 6×6 #2	745825	703946	3090	+425	+12054	1487	12061.5	3676.2	28.3624	0.12328	87°59'	7°02'
F369 6×6 #3	749991	710027	3078	-3741	+5973	1499	7047.8	2148.2	1.5966	0.21269	122°04'	12°00'
	BEARING ANGLES REPRESENT TRUE AZIMUTH FROM PHOTO STA. TO GROUND ZERO.											
	TILT ANGLES ARE MEASURED FROM THE PHOTO STA. TO SHOT CAB OR AIR ZERO.											
*	INCLUDES 1500-FOOT HEIGHT OF BALLOON										FINAL	

FORM E17(1-55 500) NAME ANALYSIS EDGERTON, GERMESHAUSEN & GRIER INC.


35
30
25
20
15
10
5
0
φ
0.1
1.0
10
TIME (msec)
FIG. 3
φ VS TIME
SHOT: WRANGELL
SYMBOL FILM NO.
60545
RAPS
60544
60536

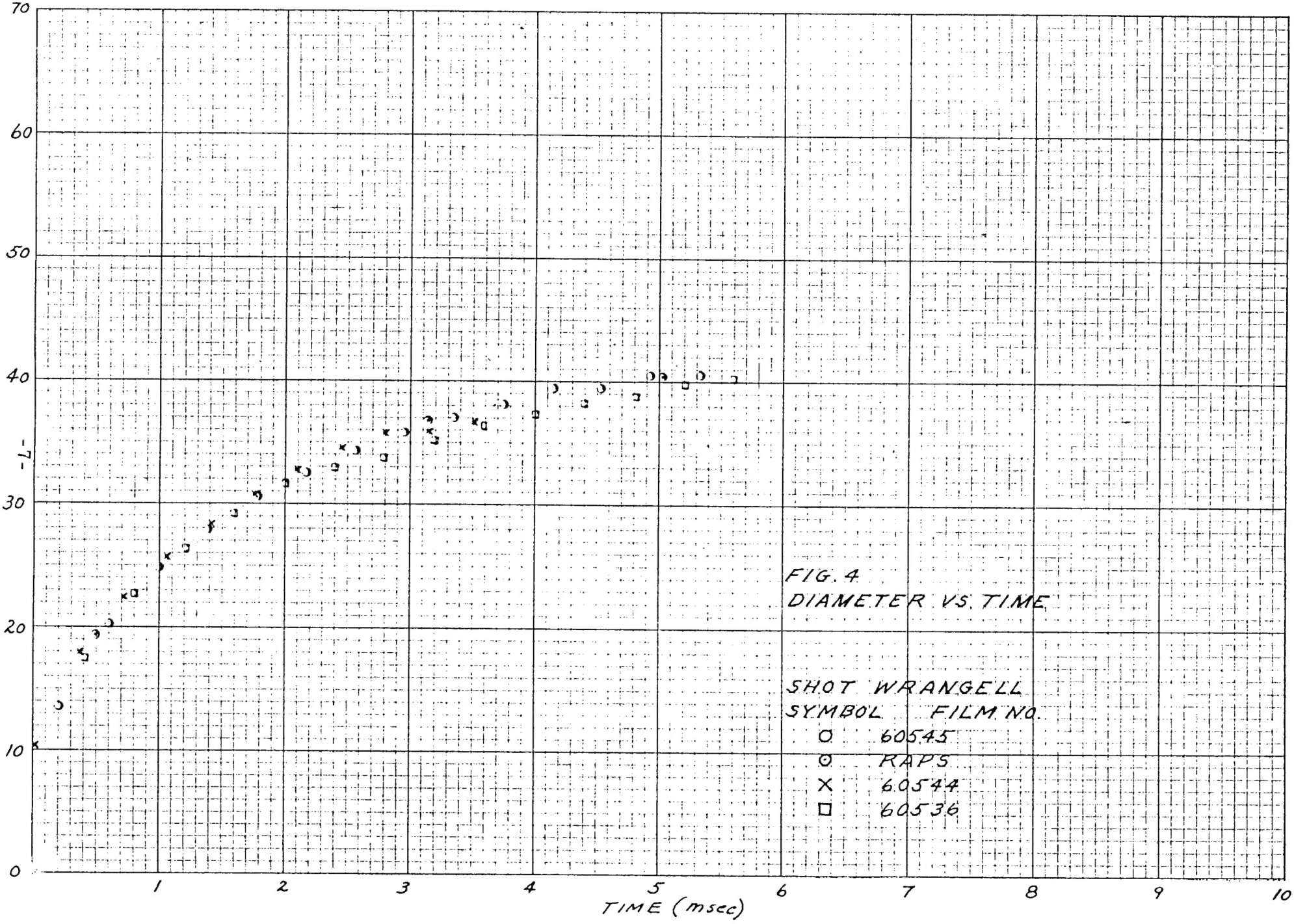


Table I

Hardtack Phase II, Wrangell

Average Diameter vs. Time

Time (msec)	Diameter (Meters)
0.5	19.5
1.0	25.0
1.5	29.0
2.0	32.0
2.5	34.0
3.0	36.0
3.5	37.5
4.0	38.5
4.5	39.0
5.0	40.0
5.5	40.5

Table II

Hardtack Phase II - Wrangell

Rapatronic Summary

Station	Film No.	Camera No.	Range (m)	F. L. (mm)	Diameter (m)	Time (ms)
F-362 (6 x 6 No. 2)	60540	R-34	3704.1	479.03	36.88	3.17
	60539	R-30	3704.1	479.30	19.41	0.49
F-369 (6 x 6 No. 3)	60548	R-4	2196.3	477.82	40.32	5.07
	60547	XR-7	2196.3	481.92	Malfunction	

STATION NO. F-362
STATION TYPE 6 x 6 No. 1
DISTANCE GZ 12,058.8 ft
DISTANCE OBJECT 12,149.3 ft

PHOTO PLAN

BRG 88°04'

EVENT WRANGELL
GZ STA. BFA
DATE 10/22/58
POSTED 11/5/58

	STATION	G Z	DIFF.	TILT
N	745844	746250	406	GZ −0°04'
E	703948	716000	12052	OBJ 7°01'
Z	3091	4577*	1486	

CAMERA			LENS			FIELD TARGET H/V	AIMING			POWER			MARKER		DELAY	FILM	PURPOSE	REMARKS
NO.	NOM SPD.	RACK POS.	FOC. MM	S/N	FILTER		OBJECT	H	V	VOLTS	SHUT RHEO.	TIME ON/OFF	TYPE	S/N				
FR	16000	=	254	4498766	ND-2		FB	0	7°00'	115AC 24DC	MAX	−1/+1	200	1	=	ECT 1229	Ex P	

REMARKS * INCLUDES 1500 FEET, HEIGHT OF BALLOON

FINAL

FORM E-60 A

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO LOADING CHART

STATION F-362 (6x6 No. 1) EVENT WRANGELL DATE 10/18/58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER.	SHUTTER RHEO.	W/M^2	
D ECT	5259-549-5	35-9	CASSETTE	60535	FR #2	=	16,000	254	ND-2	f160	MAX	1.5×10^7	

DATE FILM LOADED _____ DATE CAMERA LOADED _____ DATE EXPOSED _____

REMARKS _____

FORM E-40 FINAL

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO PLAN

STATION TYPE 6X6 #2
DISTANCE GZ 12 061.5 ft.
DISTANCE OBJECT 12152.0 ft

STATION
N 745 825
E 703 946
Z 3 090

GZ
746 250
716 000
4 577*

DIFF.
+425
+12054
1487

BRG 87°59'
TILT
GZ -0° 4'
OBJ 7°02'

EVENT WRANGELL
GZ STA. B-FA
DATE 10-22-58
POSTED

CAMERA NO.	NOM SPD.	RACK POS.	LENS FOC. MM	LENS S/N	LENS FILTER	FIELD TARGET H/V	AIMING OBJECT	AIMING H	AIMING V	POWER VOLTS	POWER SHUT RHEO.	POWER TIME ON/OFF	MARKER TYPE	MARKER S/N	DELAY	FILM	PURPOSE	REMARKS
E-34	2500	C-1	152	RC 540	ND-1 W-12	.720 .560	F.B	0°00'	+0°1' 702	120DC	40/80	-1.5/+1.5	200	12	=	MF	15.1	
E-7	2500	C-2	102	RC 128	ND-1 W-12	1.092 .834	F.B	0°00'	+0°1' 702	120DC	40/80	-1.5/+1.5	200	4	=	MF	15.1	
M-26	100	B-2	25	BF8787	W-12	12.013 8.311	CLOUD	0°00'	+0°14'20	120DC	170°	-5/+30	200	12	=	TRI-X	15.1	
R-30	4ms COIL	A-1	480	773953	ND-1	1.267 1.267	F.B.	0°00'	+0°1' 702	115AC 24DC	BULB	=	FM	5	500	RP	15.1	
R-34	40ms COIL	A-2	480	773948	=	1.267 1.267	F.B.	0°00'	+0°1' 702	115AC 24DC	BULB	=	FM	5	3000	RP	15.1	CAN #40
32 GSP	64	L B-4	9.5	240190	=	13.314 9.000	DOC	0°00'	+0°15'15	24DC	13.3°	-5/+30	=	=	=	A KDC	15.1	
5 GSP	64	R B-4	9.5	240259	=	13.314 9.000	DOC	0°00'	+0°15'15	24DC	13.3°	-5/+30	=	=	=	A KDC	15.1	
#1 35FF	2000	C-3	254	808660	ND-3	1.168 .795	F.B.	0°00'	+0°1' 702	120DC	=	-3/+2	200	4	=	ECT 1229	15.1	
							ACTUAL RP DELAYS											
							R-30			483.1 μs +			2 μs	half	coil	delay		
							R-34			3148.7 μs +			20 μs	half	coil	delay		

REMARKS * Includes 1500 feet, height of balloon

final

M E-60 A

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO LOADING CHART

STATION F362 6X6 #2 EVENT WRANGELL DATE 10-22-58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER.	SHUTTER RHEO.	W/M²	
MF	1112-9-02	16-100	H.S. Reel	60536	E-34	C-1	2500	152	ND-1 W-12	f9.0	40/80	4.5×10^{5}	
MF	↓	16-100	HS. Reel	60537	E-7	C-2	2500	102	ND-1 W-12	f6.3	40/80	1.5×10^{5}	
TRIX	5243-233-2	35-200	MIT MAG	60538	M-26	B-2	100	25	W-12	f2.3	170°	WESTON 12	
RP	6141-6426	2¼-3¼	RAP HOLDER	60539	R-30	A-1	¼ms COIL	480	ND-1	f11.0	BULB	1.5×10^{5}	500 µs
RP	↓	2¼-3¼	RAP HOLDER	60540	R-34	A-2	40 ms COIL	480	=	f11.0	BULB	3×10^{5}	3000 µs
A KDC	26407	16-50	U-MAG	60541	22 GSP	L B-4	64	9.5	=	f2.2	133°	WESTON 12	
A KDC	↓	16-50	U-MAG	60542	5 GSP	R B-4	64	9.5	=	f2.2	133°	WESTON 12	
ECT 1229	1229-393-1	35-400	DAYLight SPool	60543	35 FF		2000	254	N.D-3	f8.0	=	4.5×10^{5}	

DATE FILM LOADED 10/18/58 DATE CAMERA LOADED _____ DATE EXPOSED _____

REMARKS _____

FINAL

FORM E-40 EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO PLAN

STATION NO. F 369
STATION TYPE 6X6 #3
DISTANCE GZ 7047.8 ft.
DISTANCE OBJECT 7205.2 ft.

	STATION	GZ	DIFF.
N	749 991	746 250	-3 741
E	710 027	716 000	+ 5 973
Z	3 078	4 577*	1 499

BRG 122° 04'
TILT GZ 0° 00'
OBJ 12° 00'

EVENT WRANGELL
GZ STA. B FA
DATE 10-22-58
POSTED

CAMERA NO.	CAMERA NOM SPD.	CAMERA RACK POS.	LENS FOC. MM	LENS S/N	LENS FILTER	FIELD TARGET H/V	AIMING OBJECT	AIMING H	AIMING V	POWER VOLTS	POWER SHUT RHEO.	POWER TIME ON/OFF	MARKER TYPE	MARKER S/N	DELAY	FILM	PURPOSE	REMARKS
E 25	2500	A-2	102	RA 549	ND-1 W-12	.640 .500	F.B.	0° 00'	+12°	120 DC	40/80	-1.5/+1.5	200	101	=	MF	15.1	
E-6	2500	A-3	63	ET 1254	ND-1 W-12	1.042 .804	F.B.	0° 00'	+12°	120 DC	40/80	-1.5/+1.5	200	14	=	MF	15.1	
M-5	100	B-2	18.5	365967	W-12	9.446 7.175	CLOUD	0° 00'	+0° 19' 05"	120 DC	170°	-5/+30	200	101	=	TRI-X	15.1	
XR-7	4ms COIL	A-1	480	774693	=	.754 .754	F.B.	0° 00'	+12°	115 AC 24 DC	BULB	=	FM	26	1000	RP	15.1	
R4	40ms COIL	B-1	480	773952	=	.754 .754	F.B.	0° 00'	12°	115 AC 24 DC	BULB	=	FM	26	5000	RP	15.1	
20 GSP	64	L B-3	9.5	255 1810	=	7.920 5.352	DOC.	0° 00'	+0° 15' 15"	24 DC	133°	-5/+30	=	=	=	KDC	15.1	
66 GSP	64	R B-3	9.5	255319	=	7.920 5.352	DOC.	0° 00'	+0° 15' 15"	24 DC	133°	-5/+30	=	=	=	KDC	15.1	
							ACTUAL RAP DELAYS											
							XR-7			1078.7 μs + 2 μs			half coil				delay	
							R-4			505.2 μs + 20 μs			half coil				delay	

REMARKS * Includes 1500 feet height of balloon

final

FORM E-60 A

EDGERTON, GERMESHAUSEN & GRIER, INC.

PHOTO LOADING CHART

STATION F 369 - 6X6 #3 EVENT WRANGELL DATE 10 - 18 - 58

FILM					CAMERA			LENS		EXPOSURE			REMARKS
TYPE	EMULS. NO.	SIZE	HOLDER	PERF. NO.	NO.	RACK POS.	NOM. SPD.	FOC. MM	FILTER	APER	SHUTTER RHEO.	W/M²	
MF	1112-9-02	16-100	H.S. REEL	60544	E-25	A-2	2500	102	ND-1 W-12	f 9.0	40/80	4.5×10^5	
MF	↓	16-100	H.S. REEL	60545	E-6	A-3	2500	63	ND-1 W-12	f 6.3	40/80	1.5×10^5	
TRI-X	5243-233-2	35-200	MIT MAG	60546	M-5	B-2	100	18.5	W-12	f 13.0	170°	WEGTON 12	
RP	6141-662c-7	2¼-3¼	RAP HOLDER	60547	R 7	A-1	4 MS COIL	480	=	f 11.0	BULB	3×10^6	1000 MS
RP	↓	2¼-3¼	RAP HOLDER	60548	R 4	B-1	40 MS COIL	480	=	f 11.0	BULB	3×10^5	5000 MS
A KDC	264607	16-50	U-MAG	60549	20 GSP	L B-3	64	9.5	=	f 4.	133°		
H KDC	↓	16-50	U-MAG	60550	66 GSP	R B-3	64	9.5	=	f 5.6	133°		

DATE FILM LOADED 10/18/58 DATE CAMERA LOADED _____ DATE EXPOSED _____

REMARKS _____

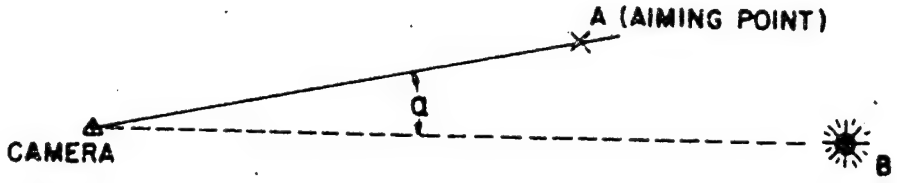
FINAL

FORM E-40

EDGERTON, GERMESHAUSEN & GRIER, INC.

CAMERA DATA & CALCULATIONS

FILM NO. 60539	STATION NO. F-362 6x6 No.2	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. R-30	EQ. AP.		DATE: 12/2/58



A. $R^{o}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0°00′	β = 7°02′	H_B = 4577 ft
$\cos\alpha$ = 1.00000	$\cos\beta$ = 0.99248	H_C = 3090 ft
CB_h = 3676.2 m	$\sin\beta$ = 0.12245	ΔH = 1487 ft = 453.2 m
$CB_h \cos\alpha \cos\beta$ = 3648.6m	$\Delta H \sin\beta$ = 55.5 m	$R^{o}/_{A}$ = 3704.1 m

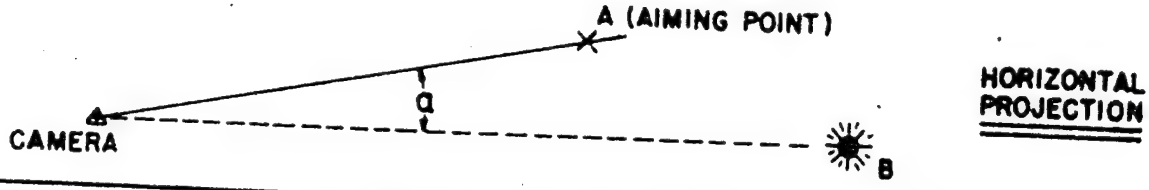
B. FOCAL LENGTH 479.30 mm

C. MAGNIFICATION FACTOR (meters/in.) 196.29

D. ZERO TIME CORRECTION 0.49 msec delay

CAMERA DATA & CALCULATIONS

FILM NO. 60540	STATION NO. F-362 6×6 No. 2	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. R-34	EQ. AP.		DATE: 12/2/58



A. $R^{O}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 7° 02′	H_B = 4577 ft
cos α = 1.00000	cos β = 0.99248	H_C = 3090 ft
CB_h = 3676.2 m	sin β = 0.12245	ΔH = 1487 ft = 453.2 m
$CB_h \cos\alpha \cos\beta$ = 3648.6 m	$\Delta H \sin\beta$ = 55.5 m	$R^{O}/_{A}$ = 3704.1 m

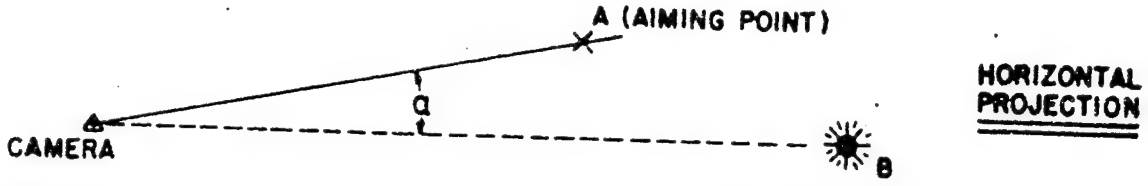
B. FOCAL LENGTH 479.03 mm

C. MAGNIFICATION FACTOR (meters/in.) 196.41

D. ZERO TIME CORRECTION 3.17 msec delay

CAMERA DATA & CALCULATIONS

FILM NO. 60548	STATION NO. E-369 6x6 #3	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. R-4	EQ. AP.		DATE: 12/2/58



A. $R^{0}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 12° 00′	H_B = 4577 ft
$\cos\alpha$ = 1.00000	$\cos\beta$ = 0.97815	H_C = 3078 ft
CB_h = 2148.2 m	$\sin\beta$ = 0.20791	ΔH = 1499 ft = 456.9 m
$CB_h \cos\alpha \cos\beta$ = 2101.3 m	$\Delta H \sin\beta$ = 95.0 m	$R^{0}/_{A}$ = 2196.3 m

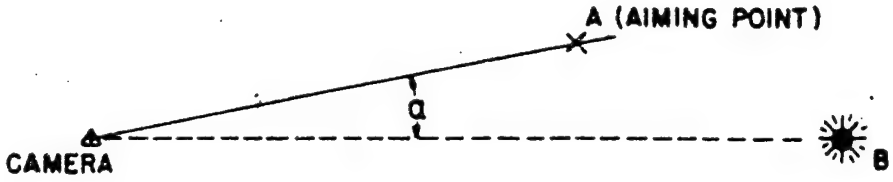
B. FOCAL LENGTH 477.82 mm

C. MAGNIFICATION FACTOR (meters/in.) 116.75

D. ZERO TIME CORRECTION 5.07 msec delay

CAMERA DATA & CALCULATIONS

FILM NO. 60545	STATION NO. E-369 6x6 No. 3	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. E-6	EQ. AP.		DATE: 12/2/58



HORIZONTAL PROJECTION

A. $R^{o}/_{A} = CB_h \cos \alpha \cos \beta + (H_B - H_C) \sin \beta$

$\alpha =$ 0° 00′	$\beta =$ 12° 00′	$H_B =$ 4577 ft
$\cos \alpha =$ 1.00000	$\cos \beta =$ 0.97815	$H_C =$ 3078 ft
$CB_h =$ 2148.2 m	$\sin \beta =$ 0.20791	$\Delta H =$ 1499 ft = 456.9 m
$CB_h \cos \alpha \cos \beta =$ 2101.3 m	$\Delta H \sin \beta =$ 95.0 m	$R^{o}/_{A} =$ 2196.3 m

B. FOCAL LENGTH 63.91 mm (ET1254)

C. MAGNIFICATION FACTOR (meters/in.) 872.9

D. ZERO TIME CORRECTION 0.20 msec 1/2 frame

DIAMETER MEASUREMENTS

SHOT WRANGELL FILM NO. 60545

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xxx.xx	FLEXOWRITER t (ms)
0	29.00	0045	0046		13.70		0.20
1		0068	0066		20.17		0.60
2		0084	0080		24.68		1.00
3		0093	0092		27.84		1.39
4		0101	0101		30.40		1.79
5		0108	0107		32.36		2.19
6		0113	0114		34.16		2.59
7		0119	0118		35.67		2.98
8		0124	0122		37.02		3.38
9		0128	0125		38.08		3.78
10		0132	0130		39.43		4.18
11		0132	0130		39.43		4.57
12		0135	0134		40.48		4.97
13		0136	0134		40.64		5.37

READ BY JEC GGO TYPED BY

DATE 11/4/58 DATE

REMARKS:

FIREBALL CALCULATIONS

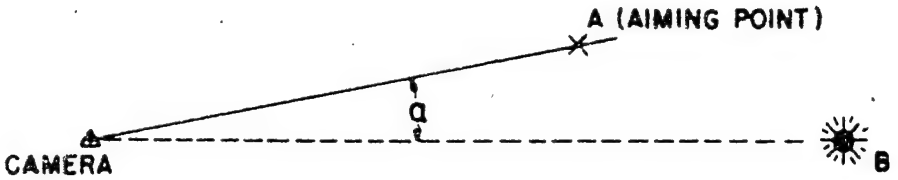
SHOT WRANGELL FILM NO. 60545

DATE

D	t	ln D	ln t	$t^{2/5}$	ϕ
13.70	.20	2.61742	1.609 45 -	.525303	26080
2017	60	3 00418	510 30 -	815107	24743
2468	1.00	3 205 92	07	1000031	24679
2784	1 39	3 326 42	32933	1140806	24403
3040	1 79	3 41442	582 26	1262262	24083
3235	219	3 476 93	78385	1368260	23650
3416	259	3 531 09	951 58	1463210	23345
3567	298	3 574 36	1 091 89	1547680	23047
3702	338	3 611 52	1 21790	1627692	22743
3808	378	3 639 76	1 329 79	1702194	22371
3943	418	3 674 60	1 43038	1772080	22250
3943	457	3 674 60	1 519 56	1836433	21470
4048	497	3 700 89	1 60343	1899084	21315
4064	537	3 704 83	1 68079	1958774	20747

CAMERA DATA & CALCULATIONS

FILM NO. 60544	STATION NO. F-369 6x6 No.3	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. E-25	EQ. AP.		DATE: 12/2/58



HORIZONTAL PROJECTION

A. $R^{\circ}_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 12° 00′	H_B = 4577 ft
$\cos\alpha$ = 1.00000	$\cos\beta$ = 0.97815	H_C = 3078 ft
CB_h = 2148.2 m	$\sin\beta$ = 0.20791	ΔH = 1499 ft = 456.9 m
$CB_h \cos\alpha \cos\beta$ = 2101.3 m	$\Delta H \sin\beta$ = 95.0 m	R°_{A} = 2196.3 m

B. FOCAL LENGTH 101.8 mm (RA 549)

C. MAGNIFICATION FACTOR (meters/in.) 547.9

D. ZERO TIME CORRECTION 0.01 msec 0.01 frame

DIAMETER MEASUREMENTS

SHOT WRANGELL FILM NO. 60544

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xxx.xx	FLEXOWRITER t (ms)
0	48.15	0090	0092		10.36		0.01
1		0157	0157		17.87		0.36
2		0197	0195		22.30		0.71
3		0225	0223		25.49		1.06
4		0247	0248		28.17		1.42
5		0270	0266		30.50		1.77
6		0286	0287		32.60		2.12
7		0305	0300		34.42		2.48
8		0316	0312		35.73		2.83
9		0315	0318		36.02		3.18
10		0320	0325		36.70		3.54

READ BY JEC GGO TYPED BY

DATE 11/4/58 DATE

REMARKS:

FIREBALL CALCULATIONS

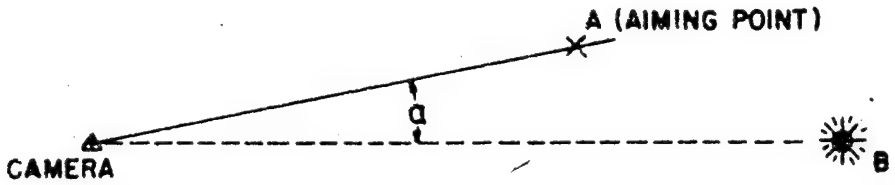
SHOT WRANGELL FILM NO. 60544

DATE

D	t	ln D	ln t	$t^{2/5}$	ϕ
10.36	.01	2.337295	4.605509-	.159064	65.130
17.97	.36	2.888317	1.021159-	.664553	26.890
22.30	.71	3.104453	.342553-	.871956	25.574
25.49	1.06	3.238821	.058822	1.023565	24.903
28.17	1.42	3.338820	.350770	1.150597	24.482
30.50	1.77	3.417771	.571703	1.256604	24.271
32.60	2.12	3.484833	.751737	1.350603	24.137
34.42	2.48	3.538868	.908118	1.438027	23.935
35.73	2.83	3.576605	1.040022	1.516022	23.568
36.02	3.18	3.584813	1.156588	1.588441	22.676
36.70	3.54	3.602984	1.266417	1.658028	22.133

CAMERA DATA & CALCULATIONS

FILM NO. 60536	STATION NO. F-362 6×6 No. 2	TEST WRANGELL	CALCULATED BY: JEC
CAMERA NO. E-34	EQ. AP.		DATE: 12/2/58



HORIZONTAL PROJECTION

A. $R^{o}/_{A} = CB_h \cos\alpha \cos\beta + (H_B - H_C) \sin\beta$

α = 0° 00′	β = 7° 02′	H_B = 4577 ft
$\cos\alpha$ = 1.00000	$\cos\beta$ = 0.99248	H_C = 3090 ft
CB_h = 3676.2 m	$\sin\beta$ = 0.12245	ΔH = 1487 ft = 453.24 m
$CB_h \cos\alpha \cos\beta$ = 3648.6 m	$\Delta H \sin\beta$ = 55.5 m	$R^{o}/_{A}$ = 3704.1 m

B. FOCAL LENGTH 152.8 mm (RC 540)

C. MAGNIFICATION FACTOR (meters/in.) 615.7

D. ZERO TIME CORRECTION 0.40 msec (0.99 fr)

DIAMETER MEASUREMENTS

SHOT WRANGELL FILM NO. 60536

Fr. No.	Mag.	D_1	D_2	D_3	D_{avg} (m)	FLEXOWRITER D_{avg} (m) xxx.xx	FLEXOWRITER t (ms)
0	48.15	0136	0139		17.59		0.40
1		0177	0178		22.70		0.80
2		0204	0207		26.28		1.21
3		0227	0228		29.10		1.61
4		0245	0248		31.53		2.02
5		0253	0261		32.87		2.42
6		0264	0264		33.77		2.82
7		0275	0274		35.11		3.23
8		0284	0285		36.39		3.63
9		0292	0293		37.41		4.04
10		0299	0300		38.31		4.44
11		0301	0307		38.88		4.85
12		0309	0313		39.78		5.25
13		0315	0316		40.35		5.65

READ BY GGO JEC TYPED BY

DATE 11/4/58 DATE

REMARKS:

FIREBALL CALCULATIONS

SHOT WRANGELL FILM NO. 60536

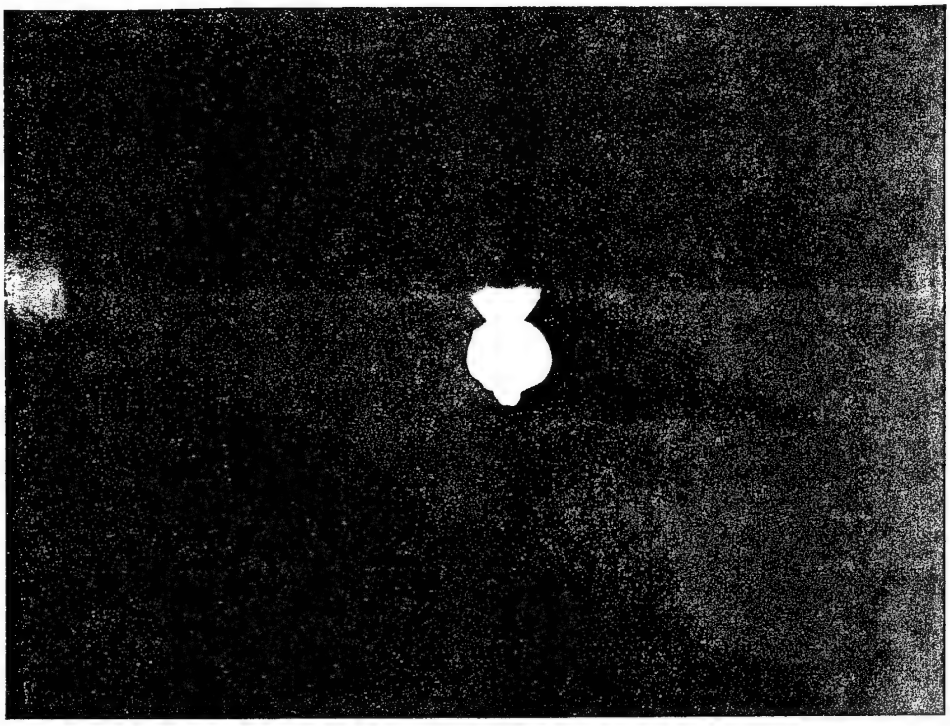
DATE

D	t	ln D	ln t	$t^{2/5}$	ϕ
17.59	.40	2.86739	-.91621	.693164	25376
2270	80	3122 30	-22311	9146 22	24818
2628	121	3268 74	19056	1079205	24351
2910	161	3370 70	47631	1209884	24051
3153	202	3450 94	70308	1324763	23900
3287	242	3492 58	88369	1424009	23082
3377	282	3519 60	1 03668	1513876	22306
3511	323	3558 53	1 17249	1598390	21965
3639	363	3594 36	1 28929	1674839	21727
3741	404	3622 01	1 39632	1748098	21400
3831	444	3645 78	1 49071	1815364	21103
3888	485	3660 56	1 57900	1880618	20874
3978	525	3683 44	1 65820	1941155	20492
4035	565	3697 67	1 73160	1998986	20185

APPENDIX A

HARDTACK PHASE II, WRANGELL

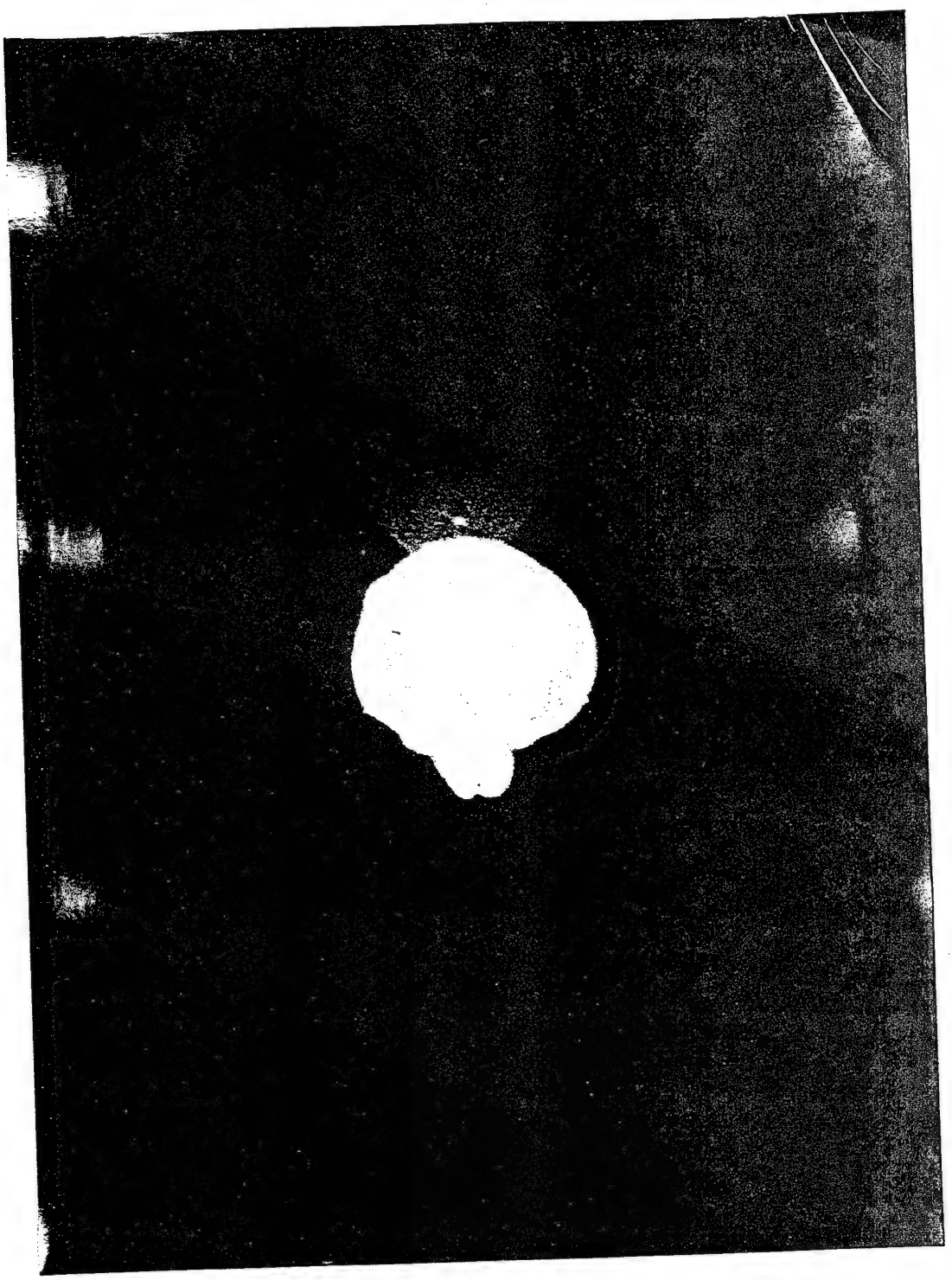
PHOTOGRAPHIC EXAMPLES



Camera: E-34

Station: F-362 (6 x 6 No. 2)

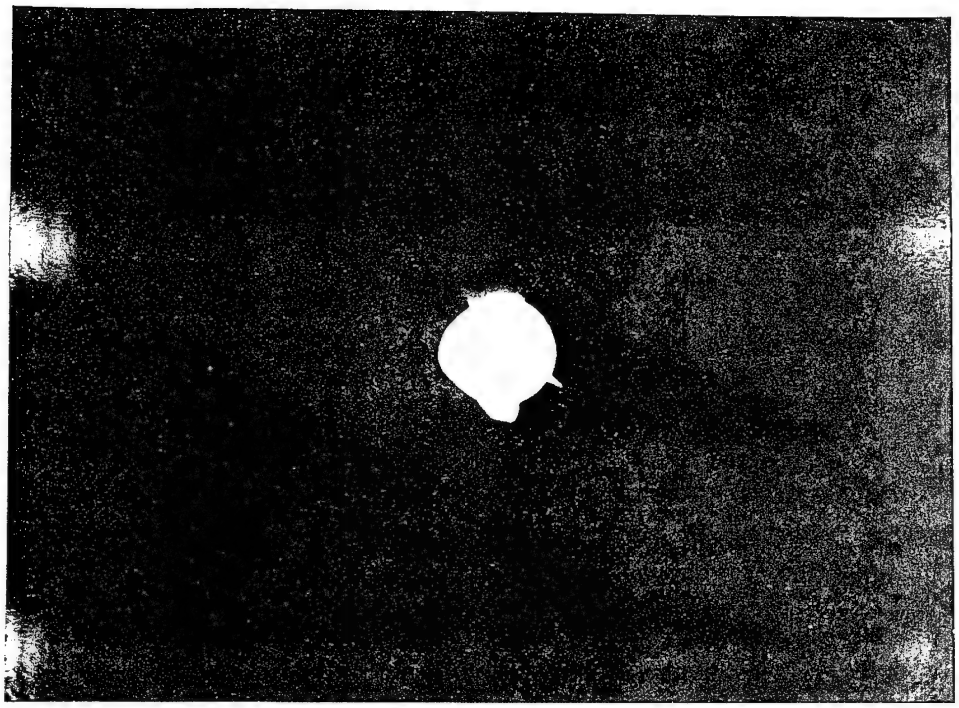
Time: 0.40 msec



Camera: R-30

Station: F-362 (6 x 6 No. 2)

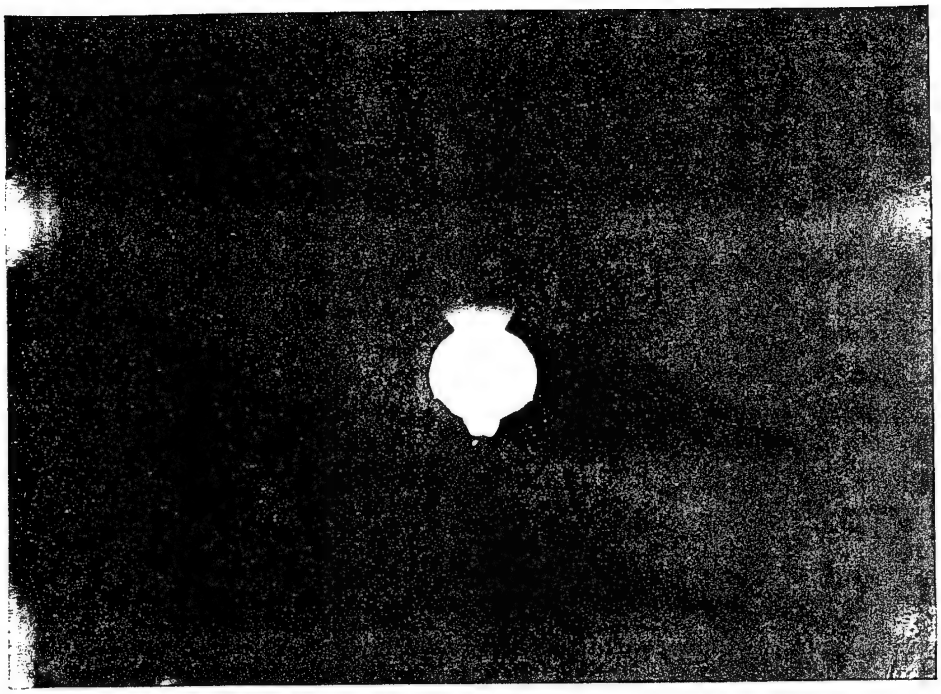
Time: 0.49 msec



Camera: E-25

Station: F-369 (6 x 6 No. 3)

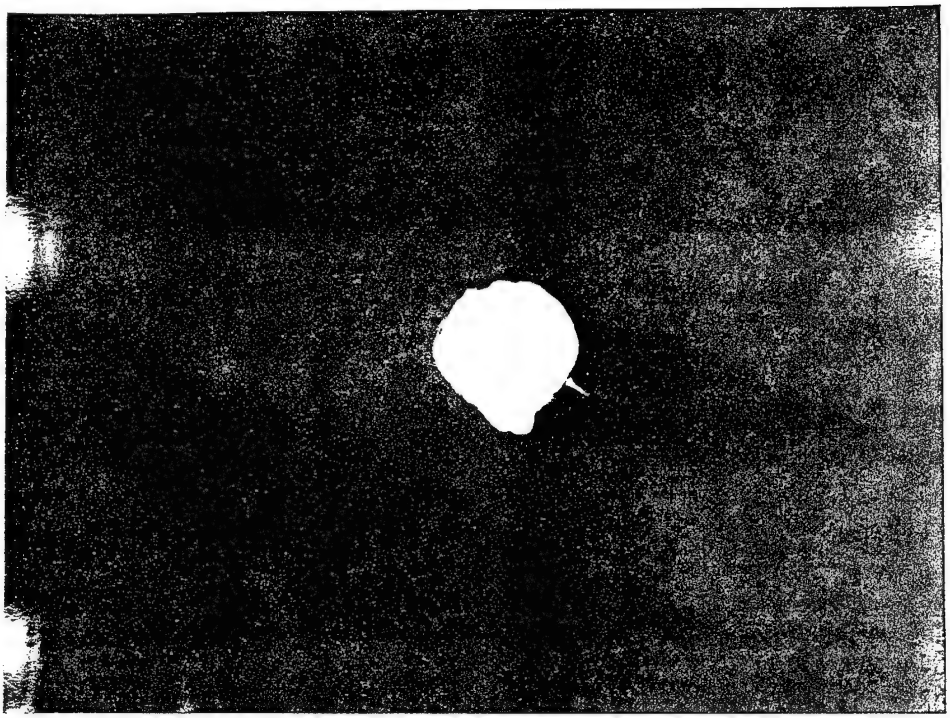
Time: 0.71 msec



Camera: E-34

Station: F-362 (6 x 6 No. 2)

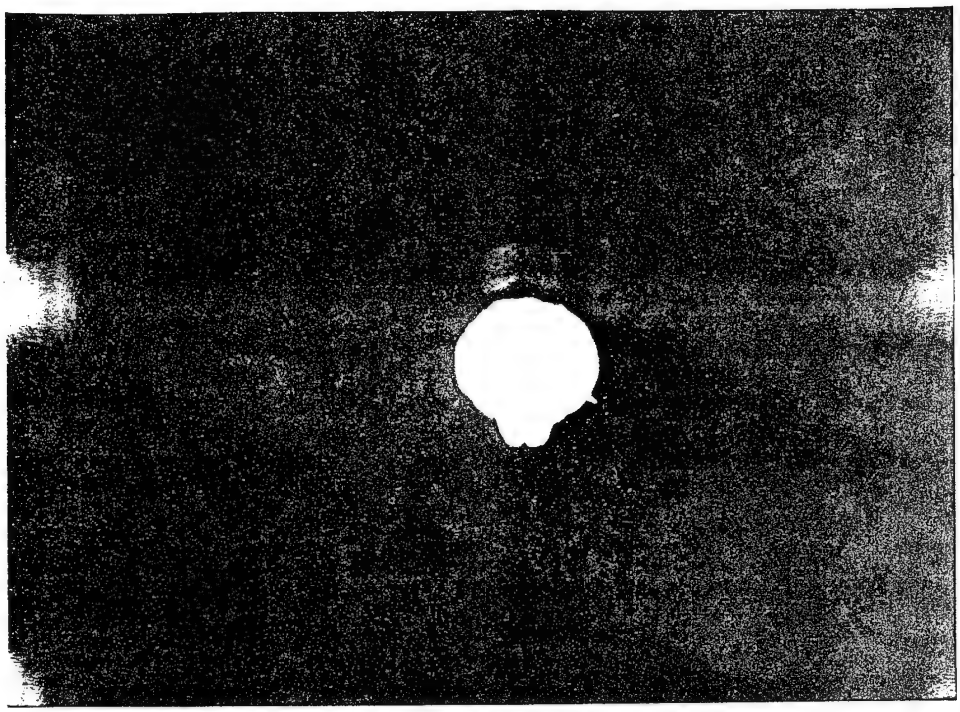
Time: 0.80 msec



Camera: E-2_5

Station: F-369 (6 x 6 No. 3)

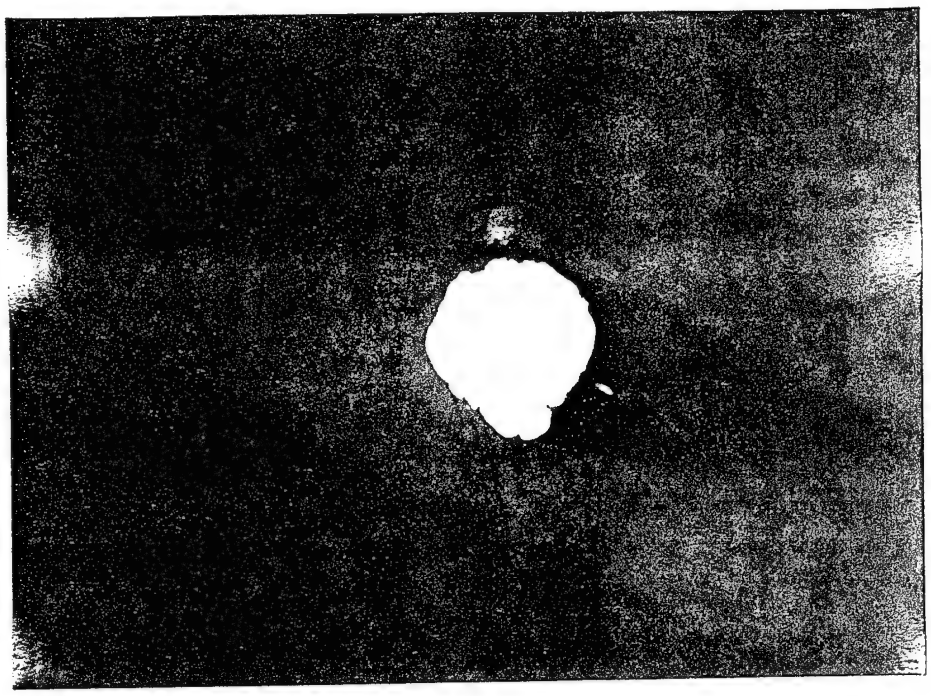
Time: 1.42 msec



Camera: E-34

Station: F-362 (6 x 6 No. 2)

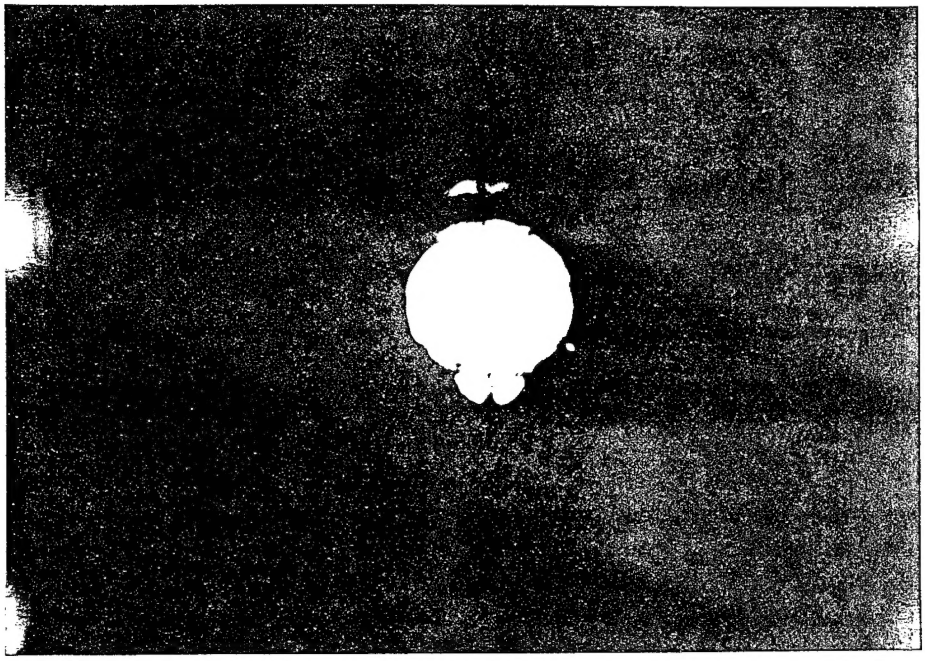
Time: 2.02 msec



Camera: E-25

Station: F-369 (6 x 6 No. 3)

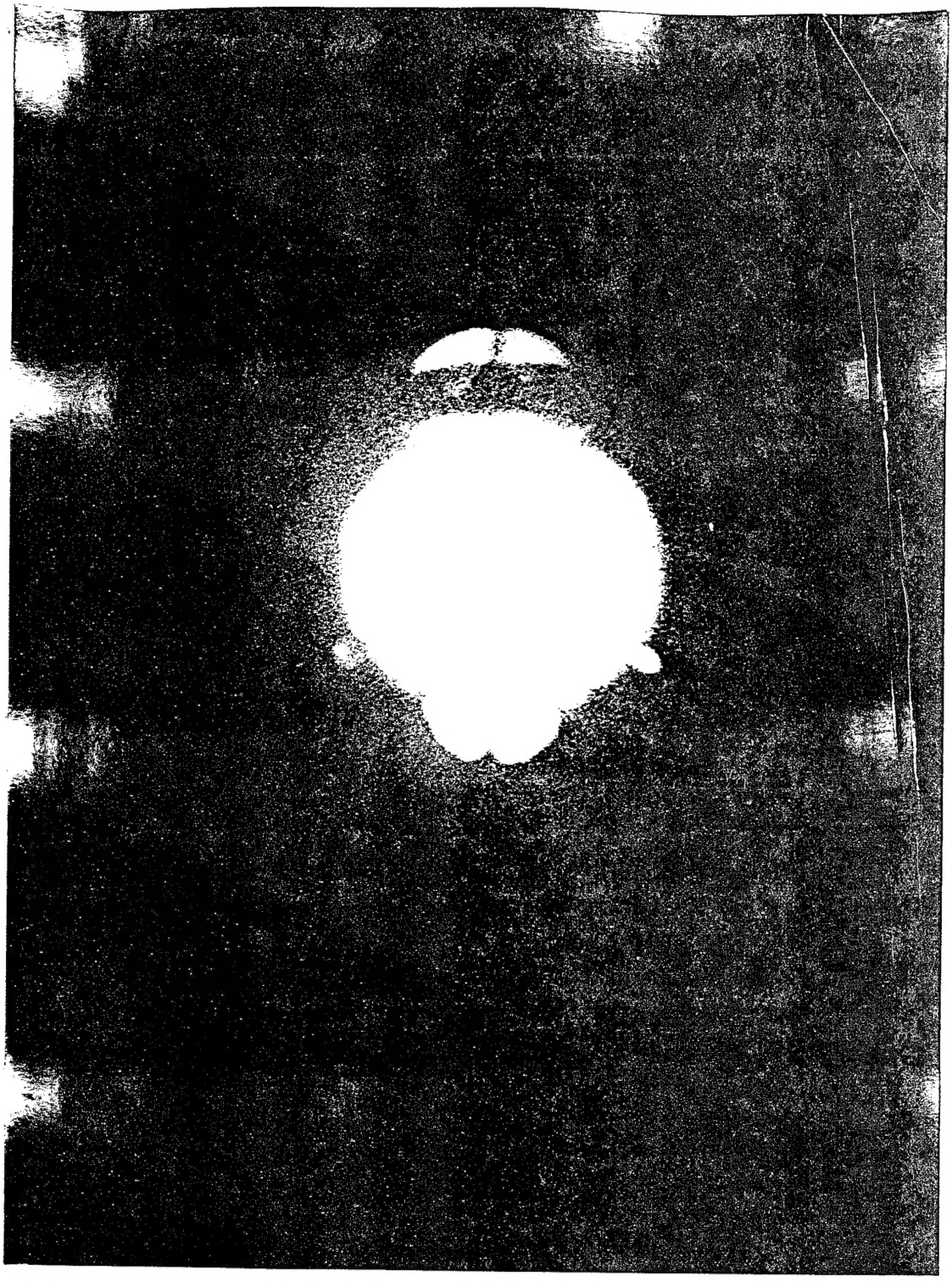
Time: 2.48 msec



Camera: E-34

Station: F-362 (6 x 6 No. 2)

Time: 3.63 msec



Camera: R-34

Station: F-362 (6 x 6 No. 2)

Time: 3.17 msec

Camera: R-4

Station: F-369 (6 x 6 No. 3)

Time: 5.07 msec

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